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Current OCT Plaque Vulnerability: The past is the Mirror of Future?

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Harvard Medical School
Massachusetts General Hospital

A Teaching Affiliate of Harvard Medical School

OCT

- Background
- Ex Vivo Validation
- In vivo Plaque Characterization
- Limitations
- Recent Development

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History

1993	OCT, Ophthalmology	MIT
1995	1.3 micron, high resolution source	
1996	Radial scanning catheter prototype	
1998	Non-reciprocal interferometer	
1998	MGH Cardiac OCT Group	MGH
	GI, ENT, Urology, GNY	
1999	Clinically viable system for cardiology	
	3.2 F catheter	
	Optical rotary junction	
2000	FIM study in cardiology	
2004	In vivo plaque characterization	
2006	FD-OCT	

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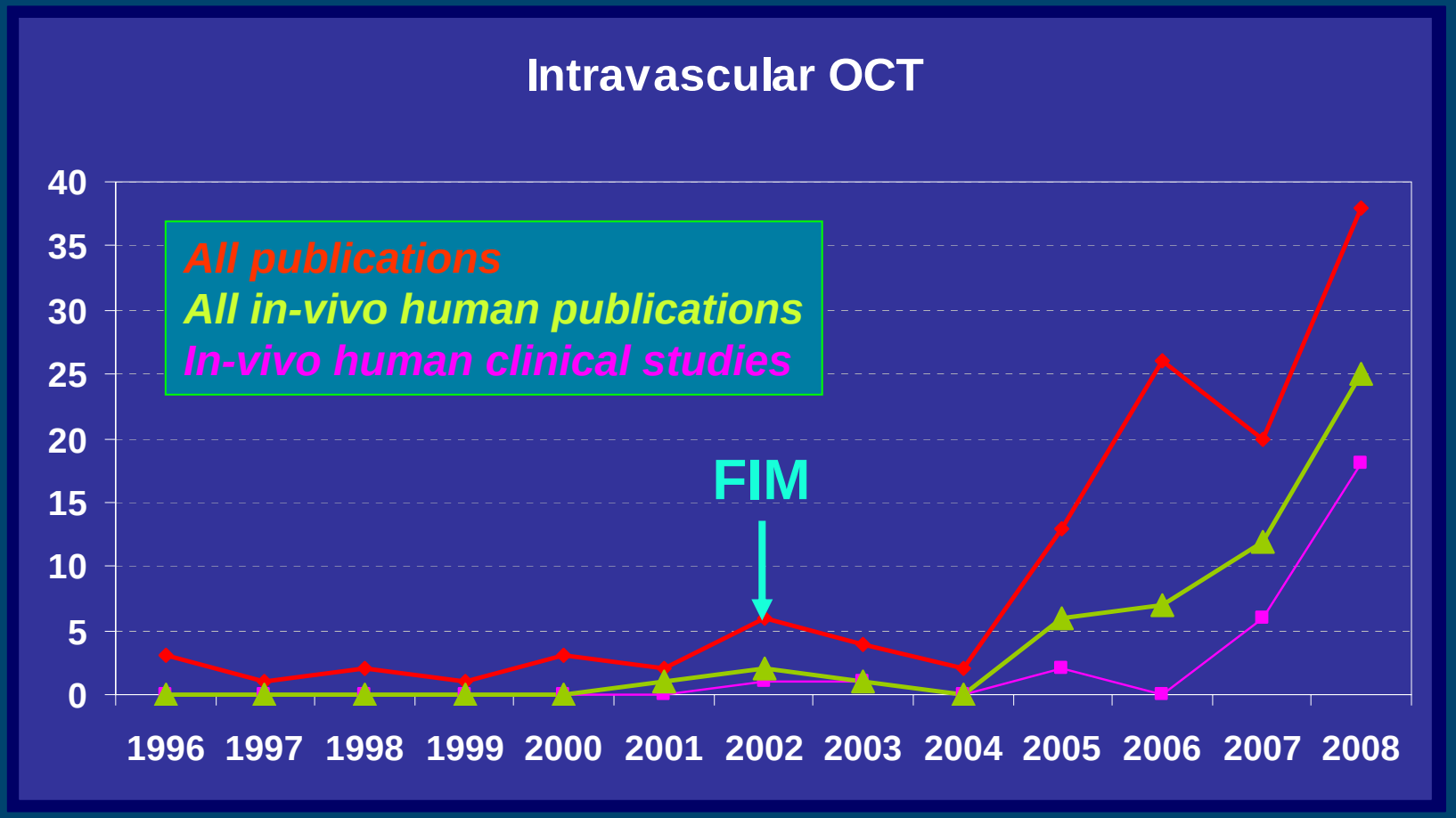
Publications



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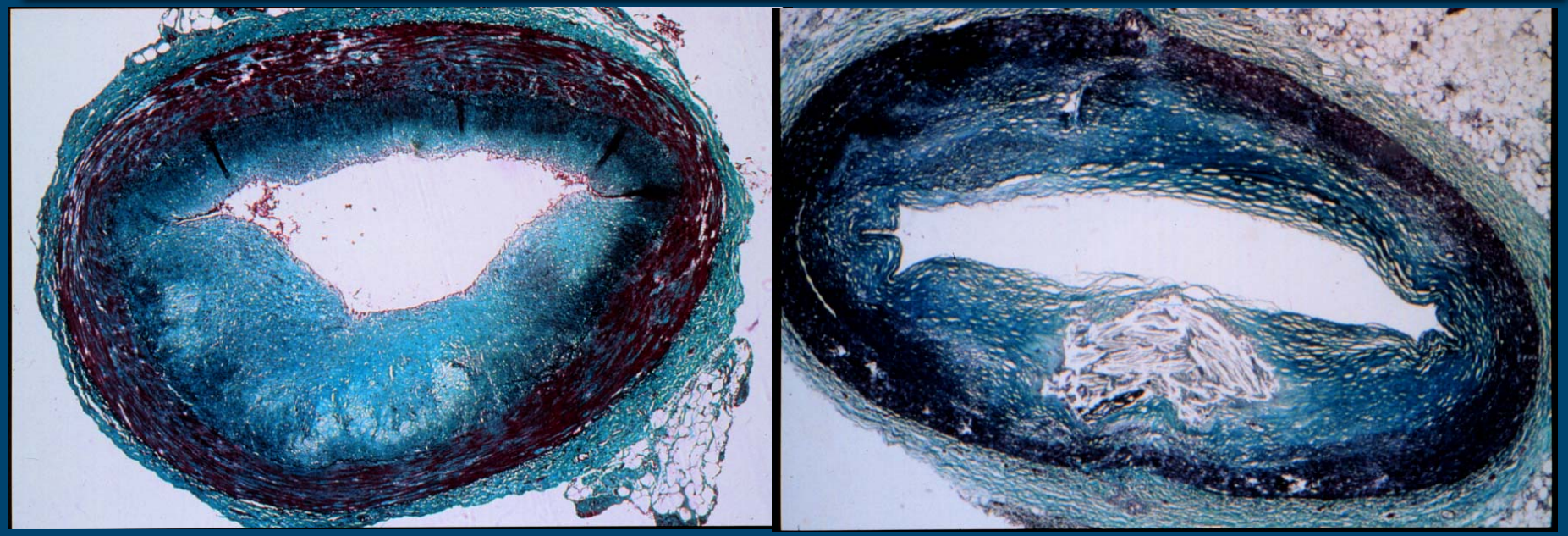
Stable vs Vulnerable Plaque



Stable Plaque

- Low lipid conc.
- Thick fibrous cap
- Low mΦ density

Vulnerable Plaque

- High lipid conc.
- Thin fibrous cap
- High mΦ density

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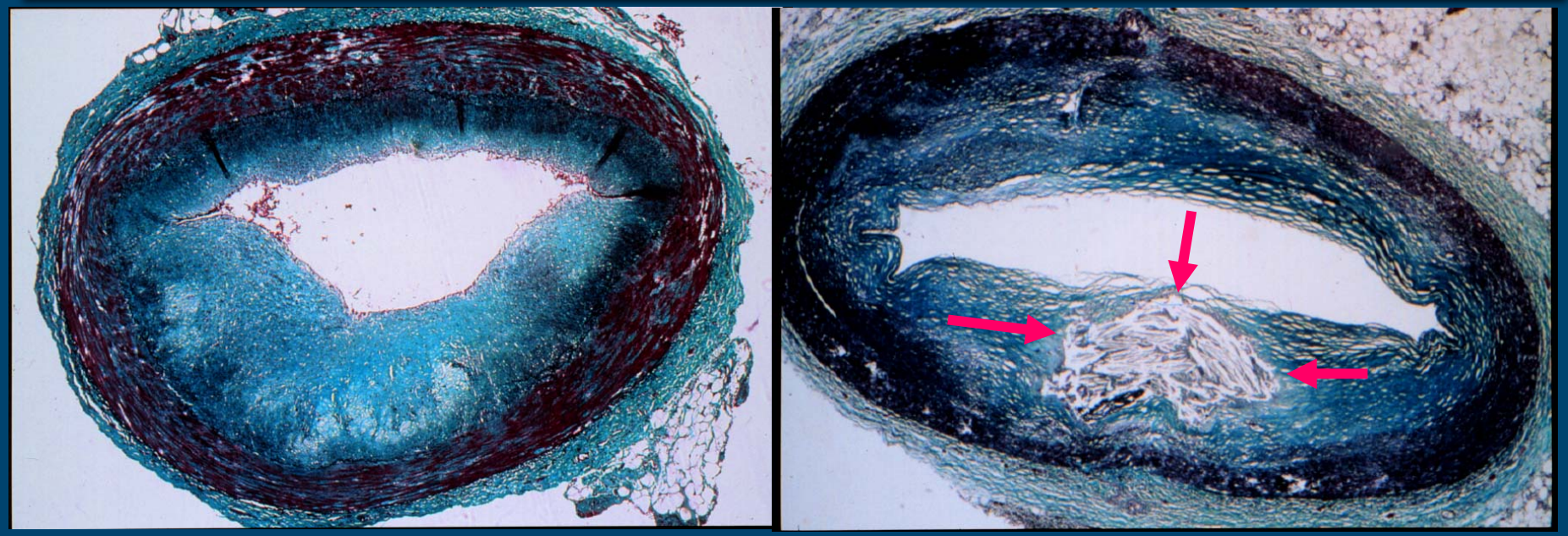
Stable vs Vulnerable Plaque



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Ex Vivo Study Results

Fibrous	SENS	**.87**	PPV	**.88**
	SPEC	**.97**	NPV	**.96**
Calcific	SENS	**.95**	PPV	**1.0**
	SPEC	**1.0**	NPV	**.95**
Lipid pool	SENS	**.92**	PPV	**.81**
	SPEC	**.94**	NPV	**.97**

Yabushita, .. Jang, Bouma, Tearney. Circulation 2002

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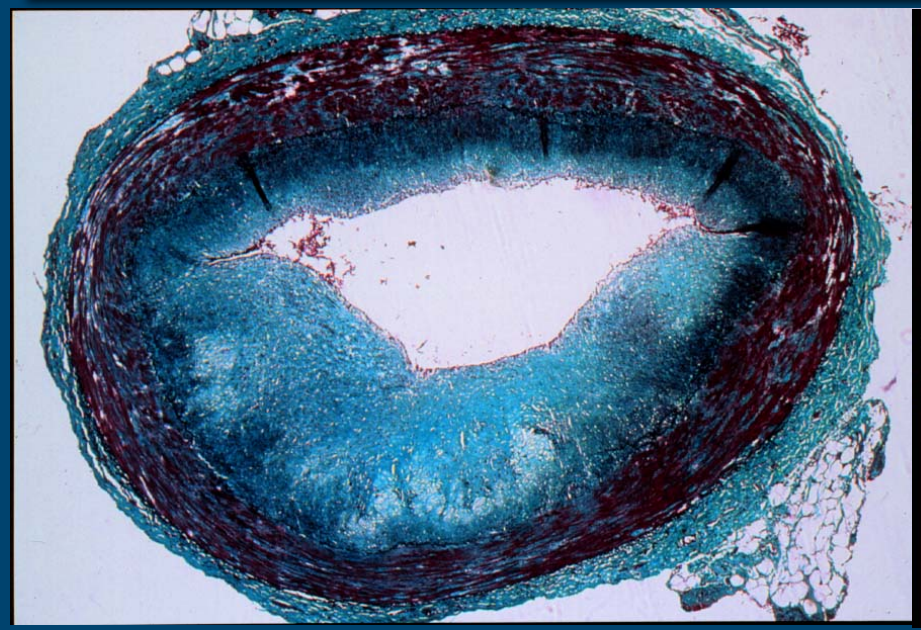
Stable vs Vulnerable Plaque



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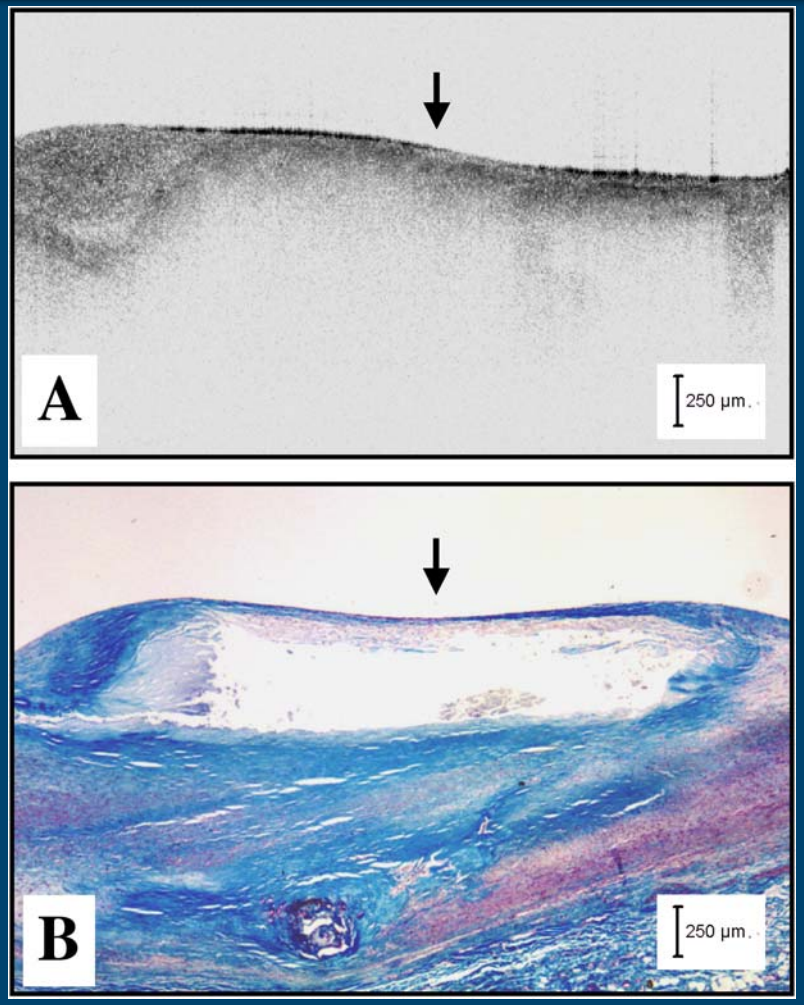
OCT and histology



fibrous cap thickness;
44.1 µm by OCT

fibrous cap thickness;
40.4 µm by histology
(Masson's trichrome;
original magnification 40X)

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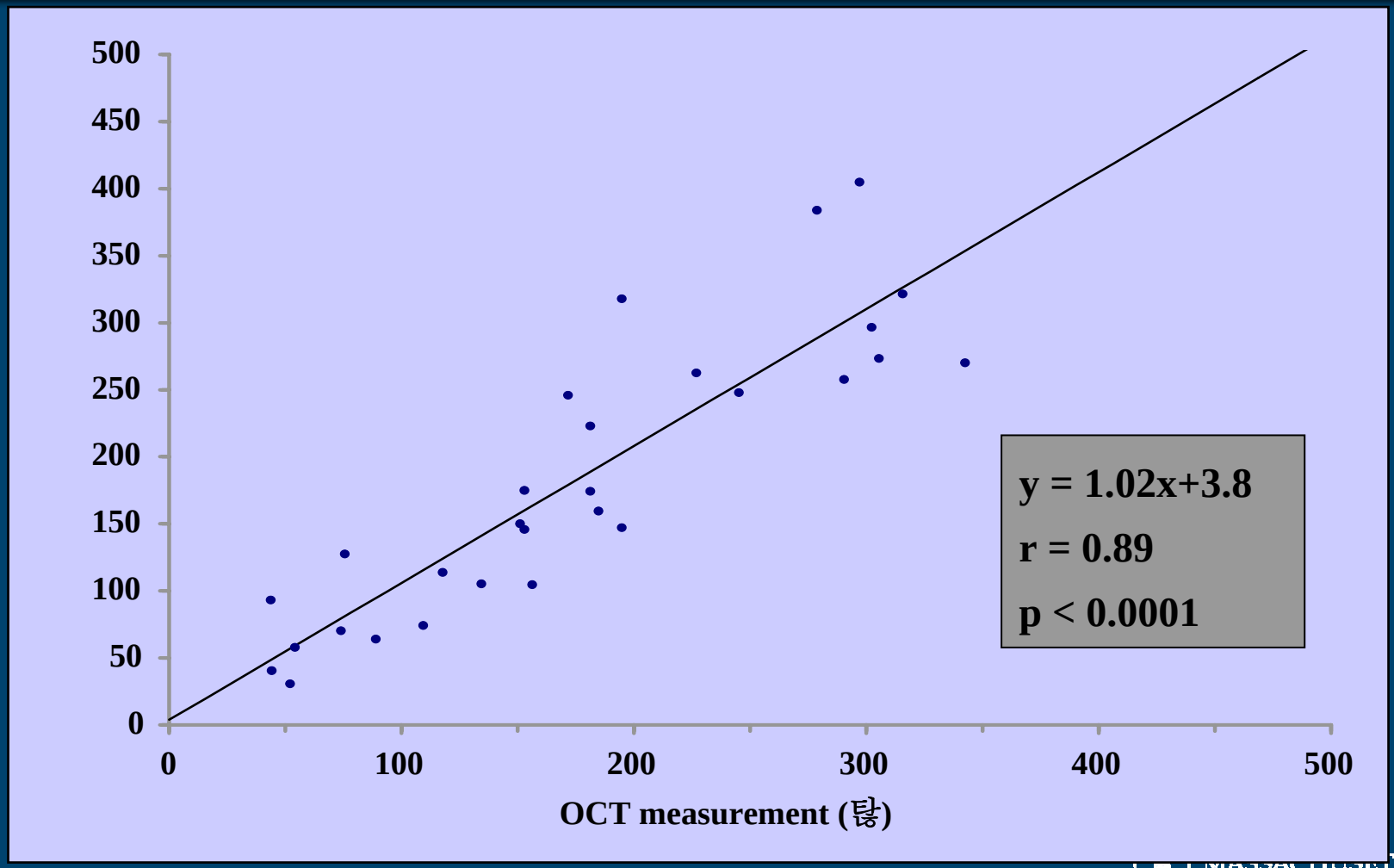
Correlation between OCT and histology



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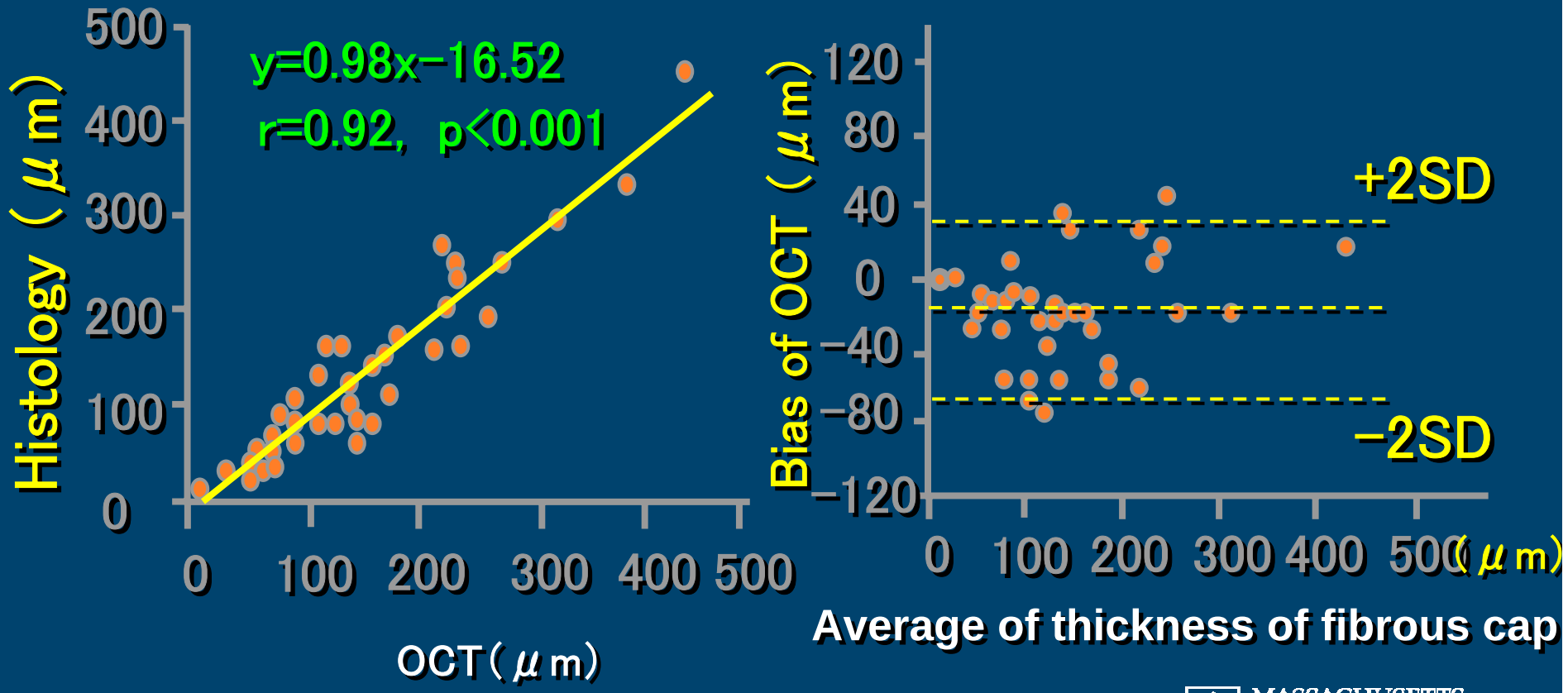
Thickness of fibrous caps
Histology vs OCT



Kume, Akasaka. Am Heart J . 152:755, 2006

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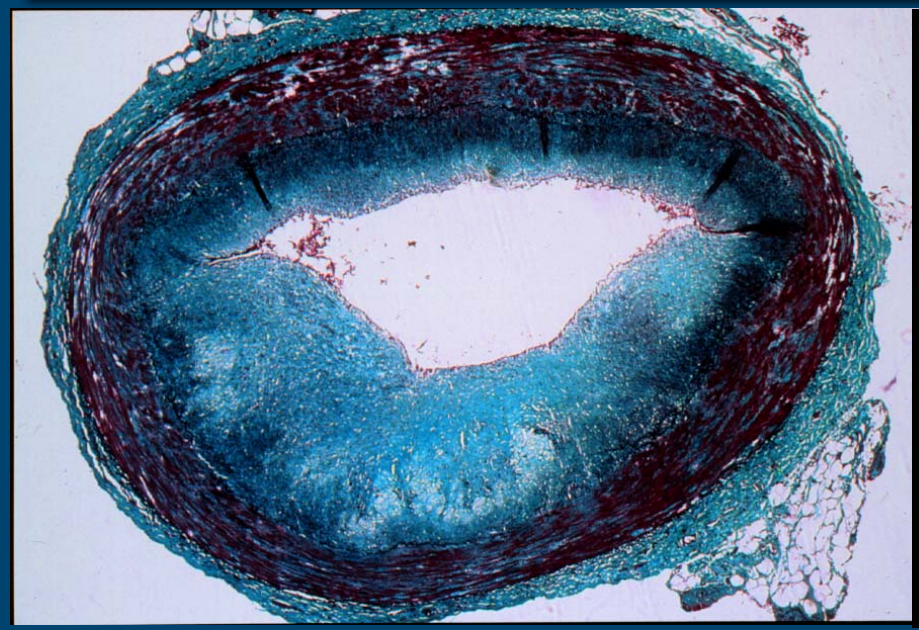
Stable vs Vulnerable Plaque



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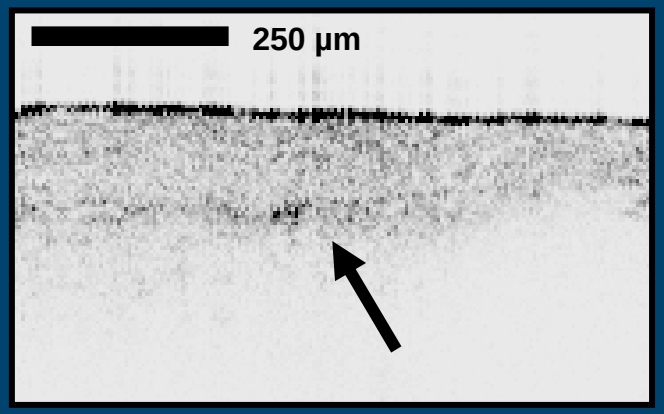
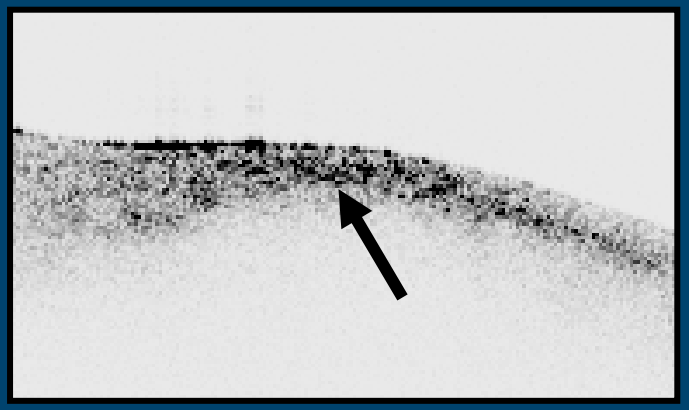
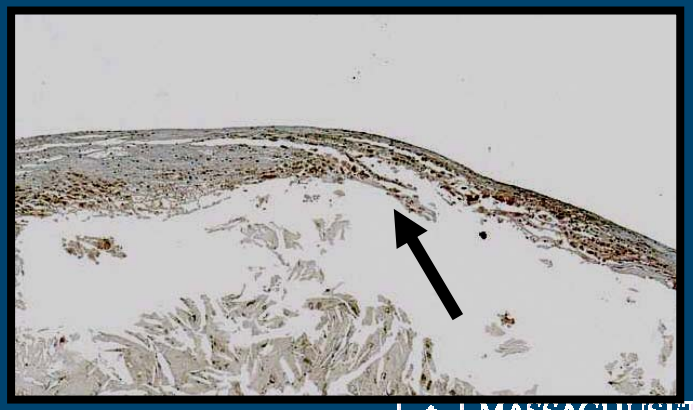
Macrophage Study

	Low Mϕ	High Mϕ
OCT		
CD68		

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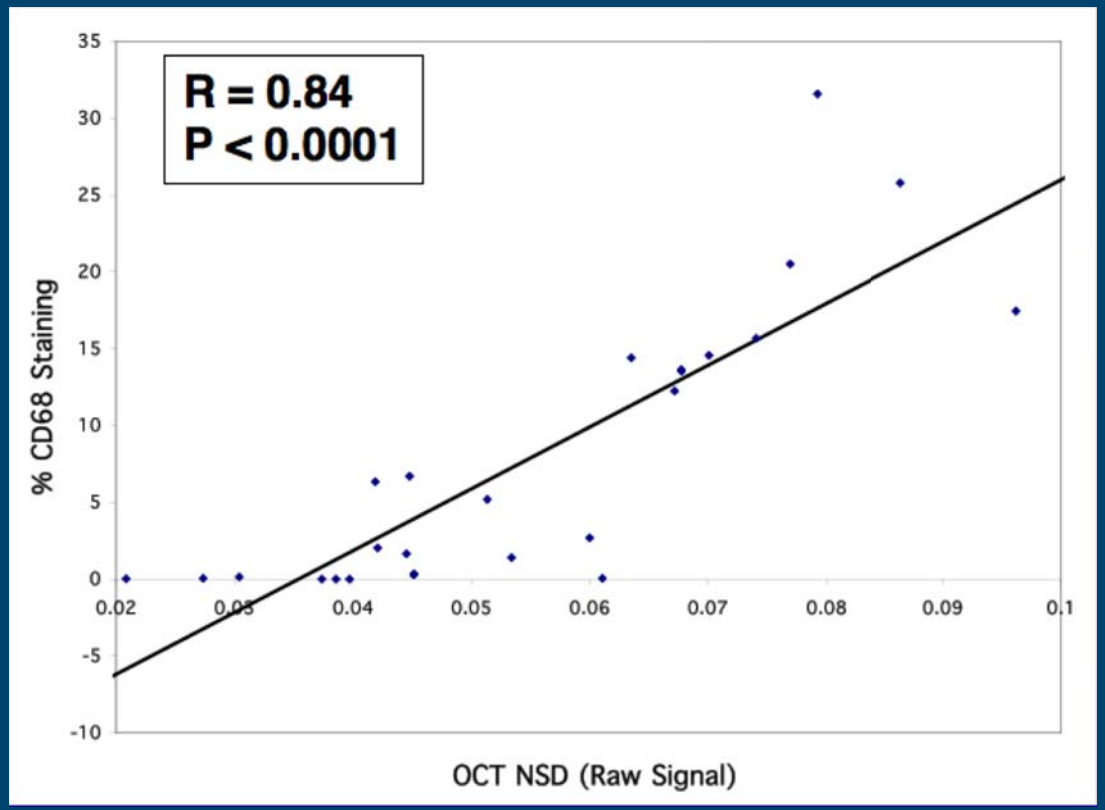
Linear NSD vs. CD68



CD68 % area > 10 % - NSD cutoff 6.2%

SENS 100% (70-100%)

SPEC 100% (60 -100%)

Tearney, .. Jang, Bouma. Circulation 2003

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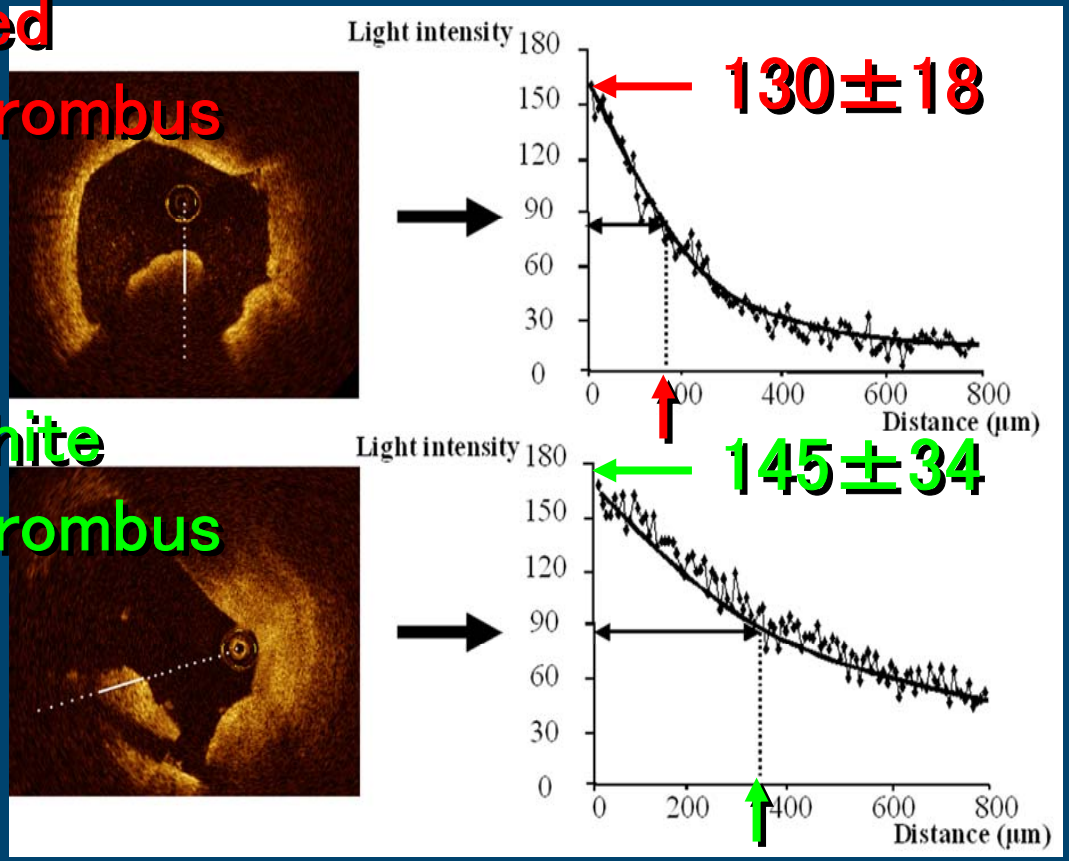
Differentiation between red and white thrombus

Peak intensity

Intensity half distance

Red thrombus



White thrombus

* p = 0.0001

Kume, Akasaka. Am J Cardiol . 2006, 97:1713

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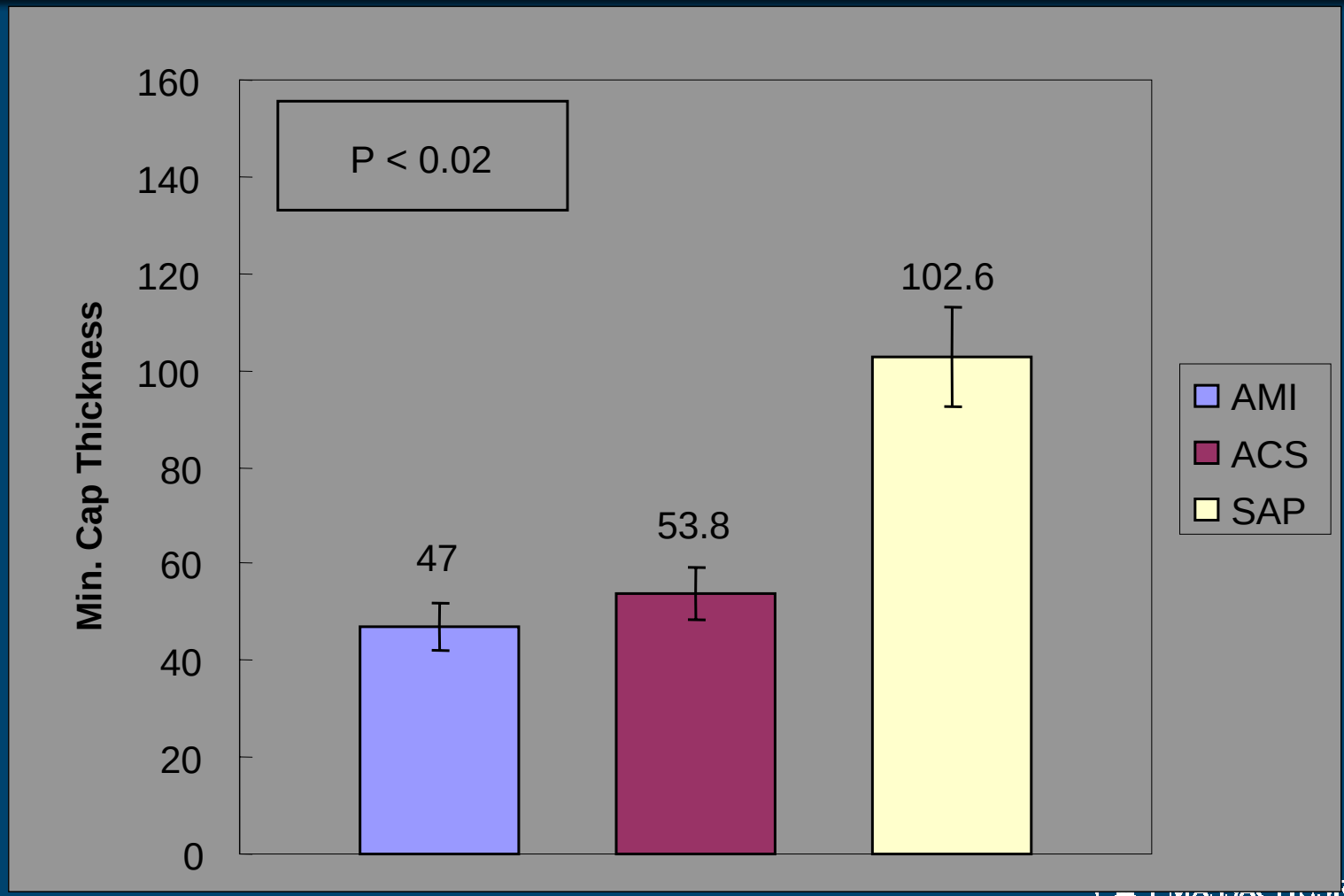
Cap Thickness



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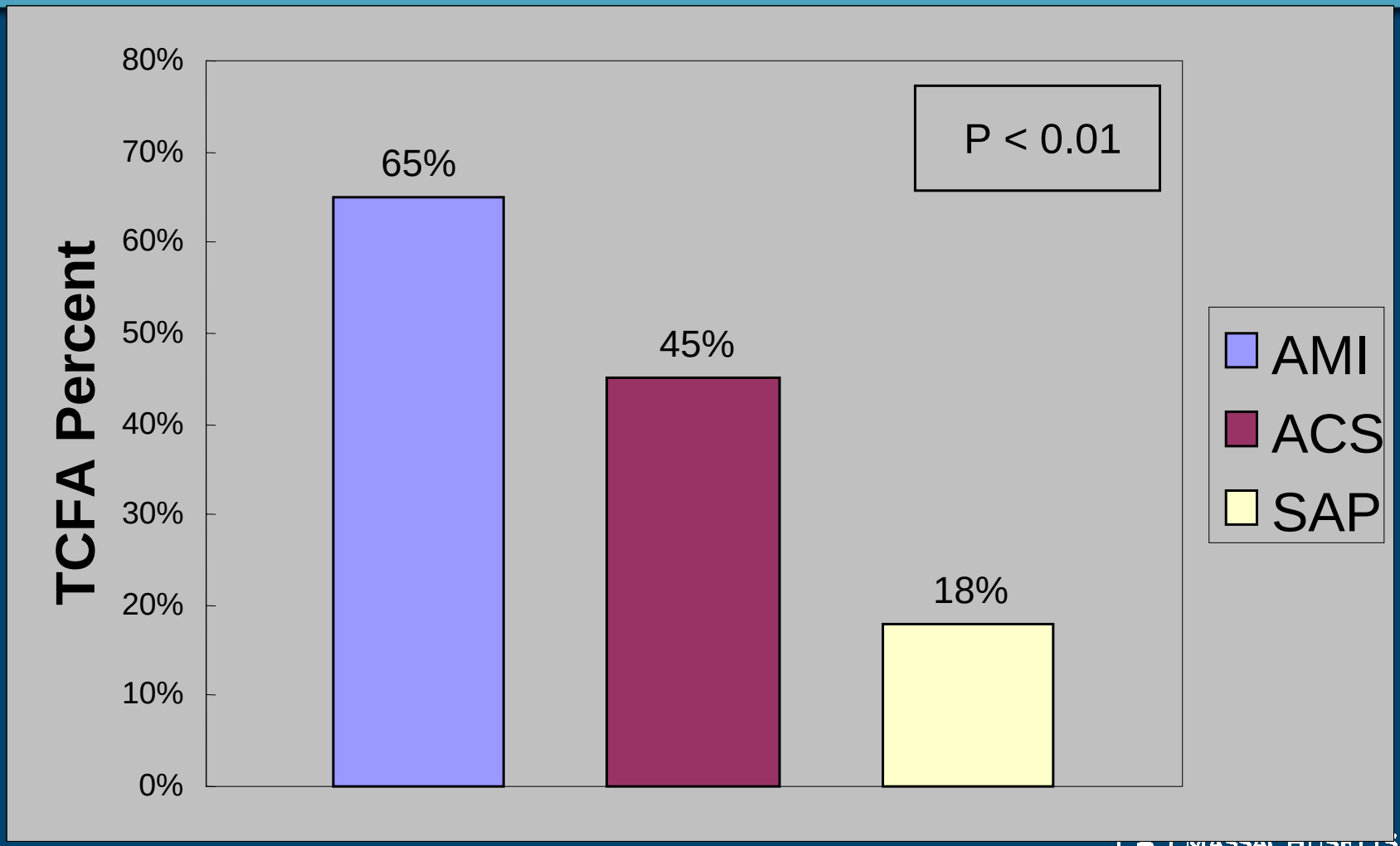
Prevalence of TCFA
(Thin Cap Fibro Atheroma)



Jang, Bouma. Circulation 2005

AMI v ACS v SAP

	AMI (n=20/30/35)	ACS (n=20/24/--)	SAP (n=17/31/20)
LRP (%)	90/93/--	75/71/--	58/42/--
FCT (μm)	47/49/--	54/79/--	103/196/--
TCFA (%)	72/83/77	50/46/--	20/3/25

Jang/Akasaka/Fujii

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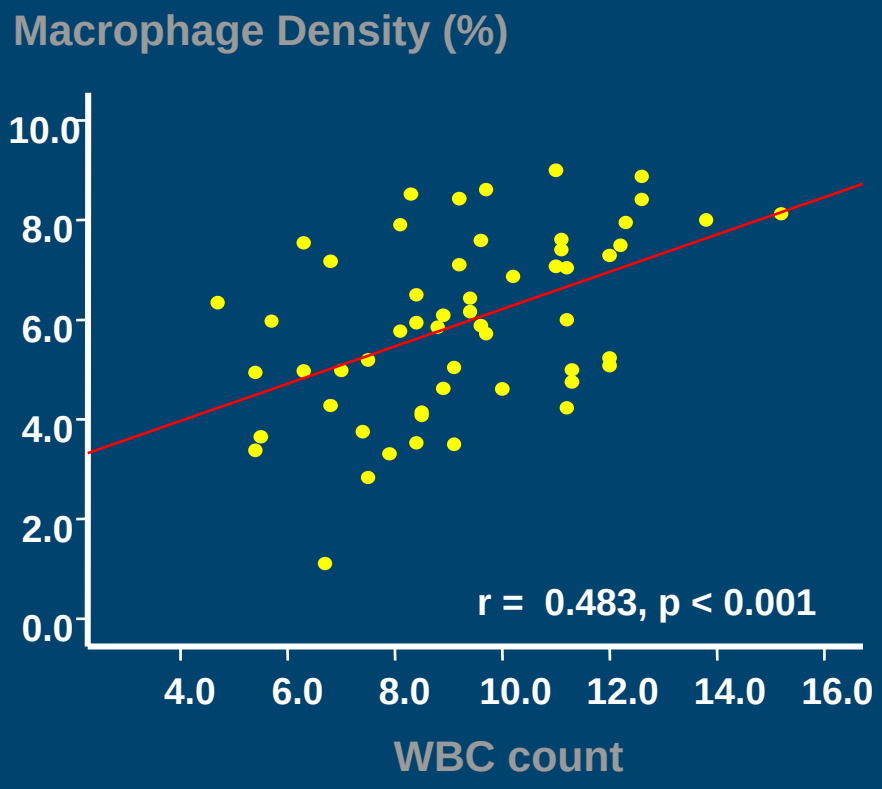
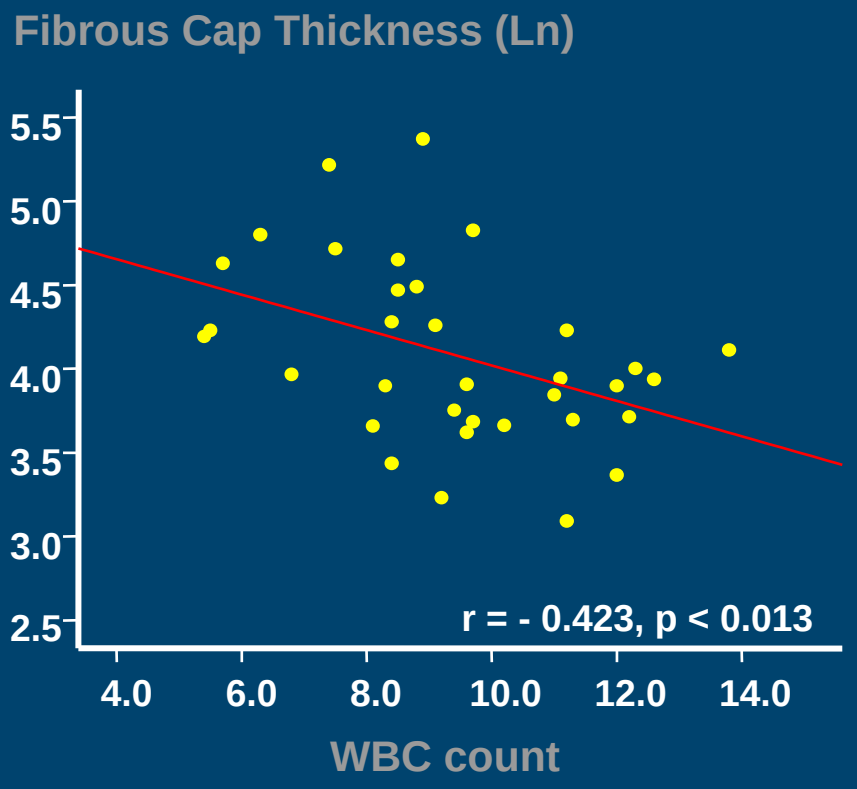
Correlation of WBC count with Macrophage Density and Fibrous Cap Thickness





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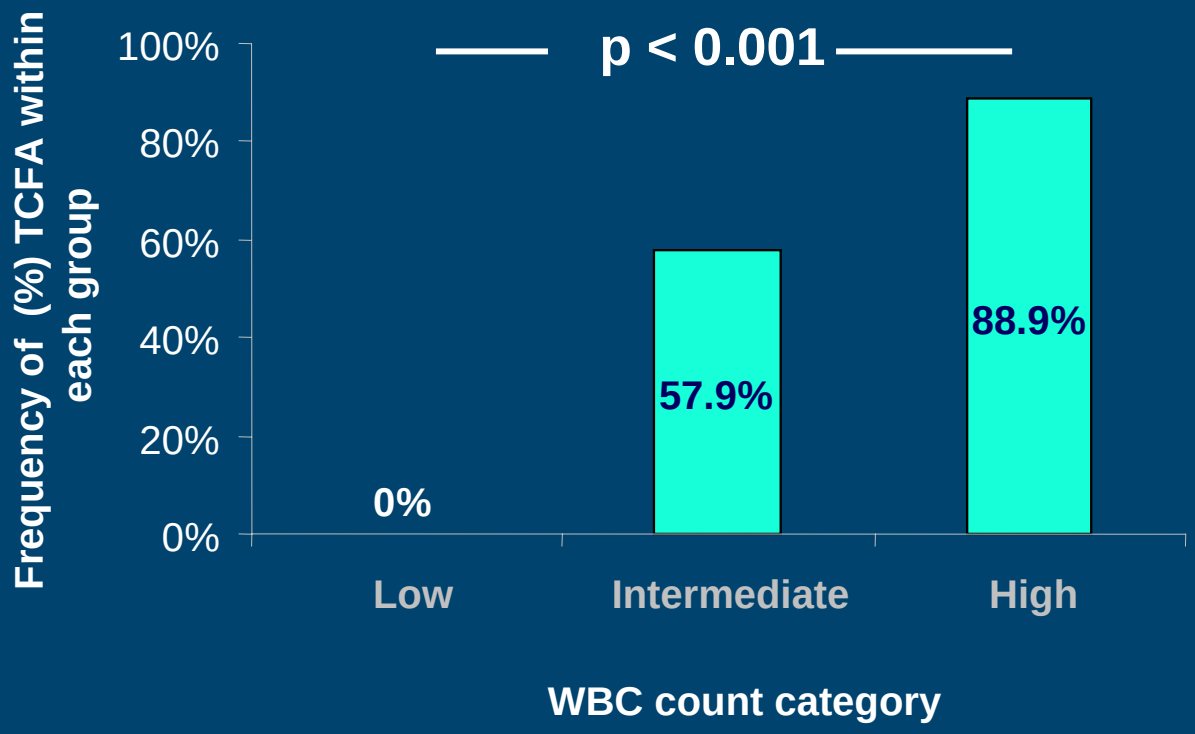
Frequency of TCFA in relation to baseline WBC count categories



Raffel, Jang. ATVB 2007.

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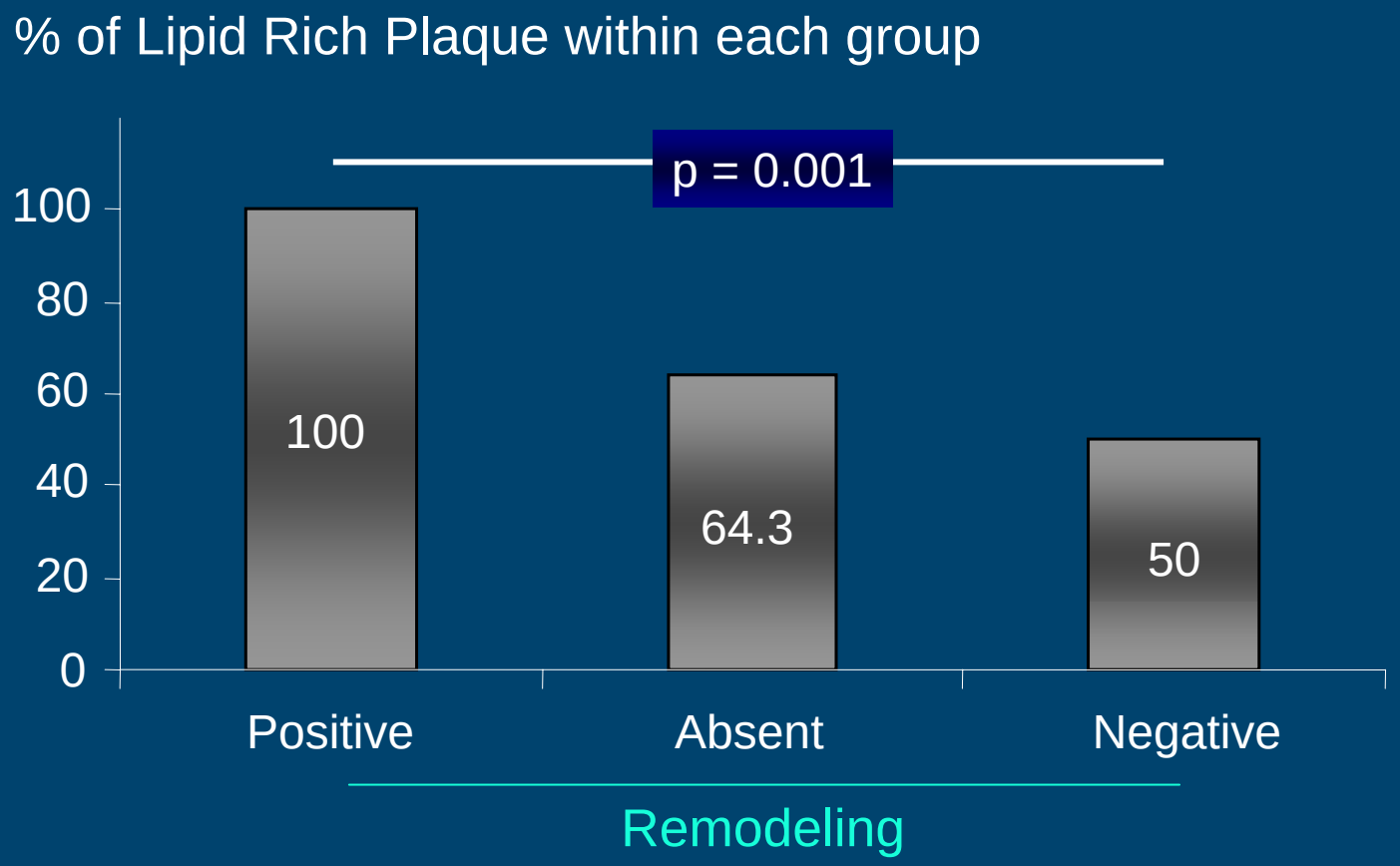
Remodeling vs Lipid Rich Plaque



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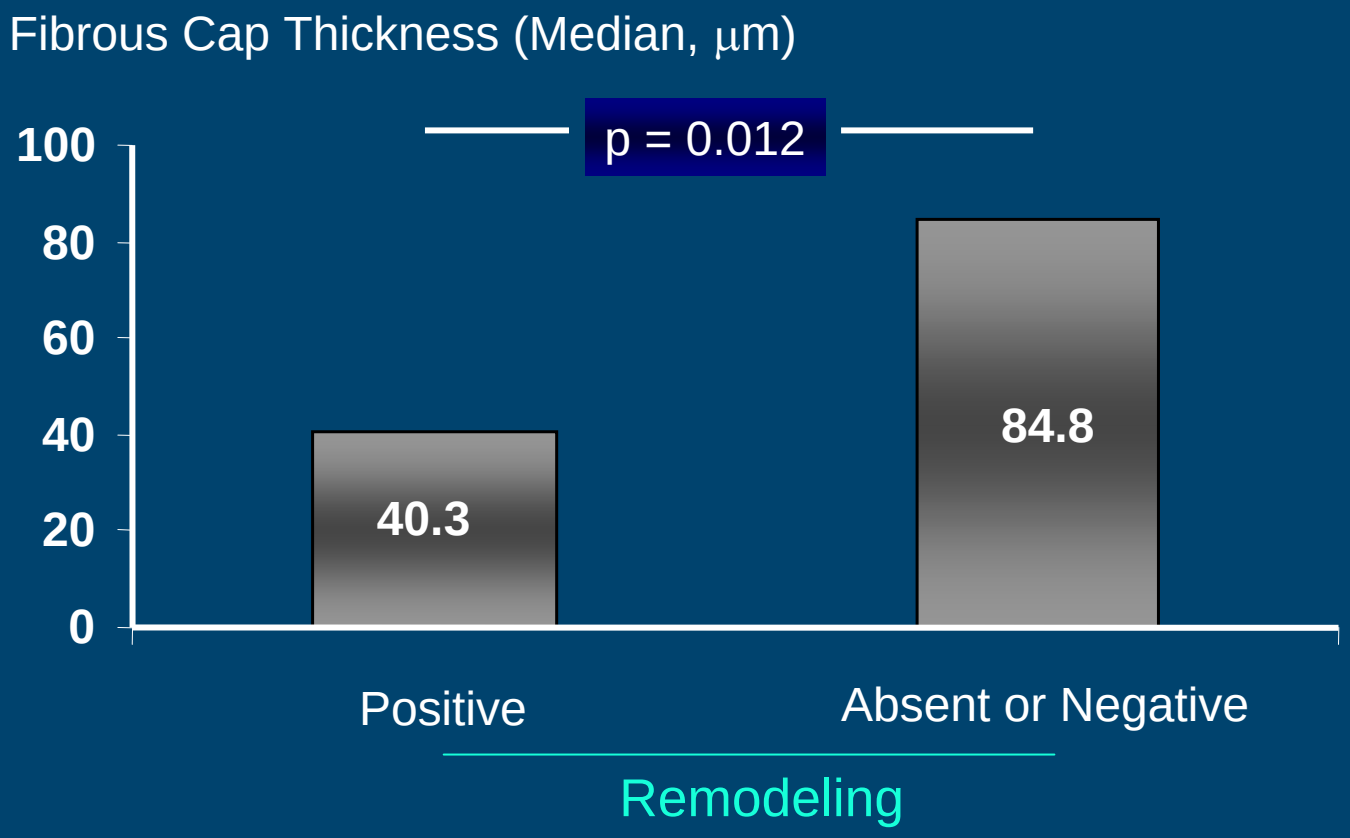
Remodeling vs Fibrous Cap thickness



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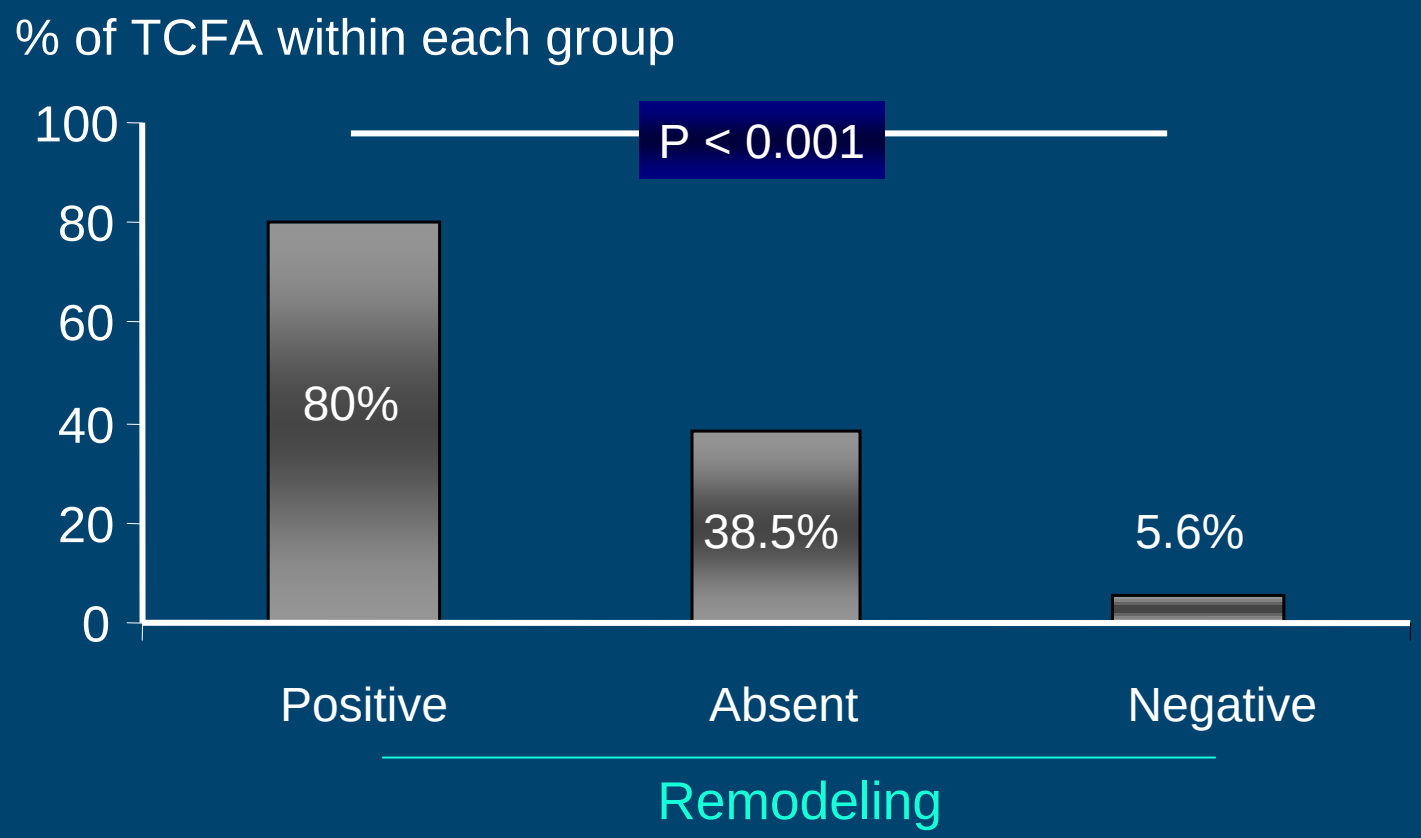
Remodeling vs TCFA



Raffel, Jang. EHJ 2008

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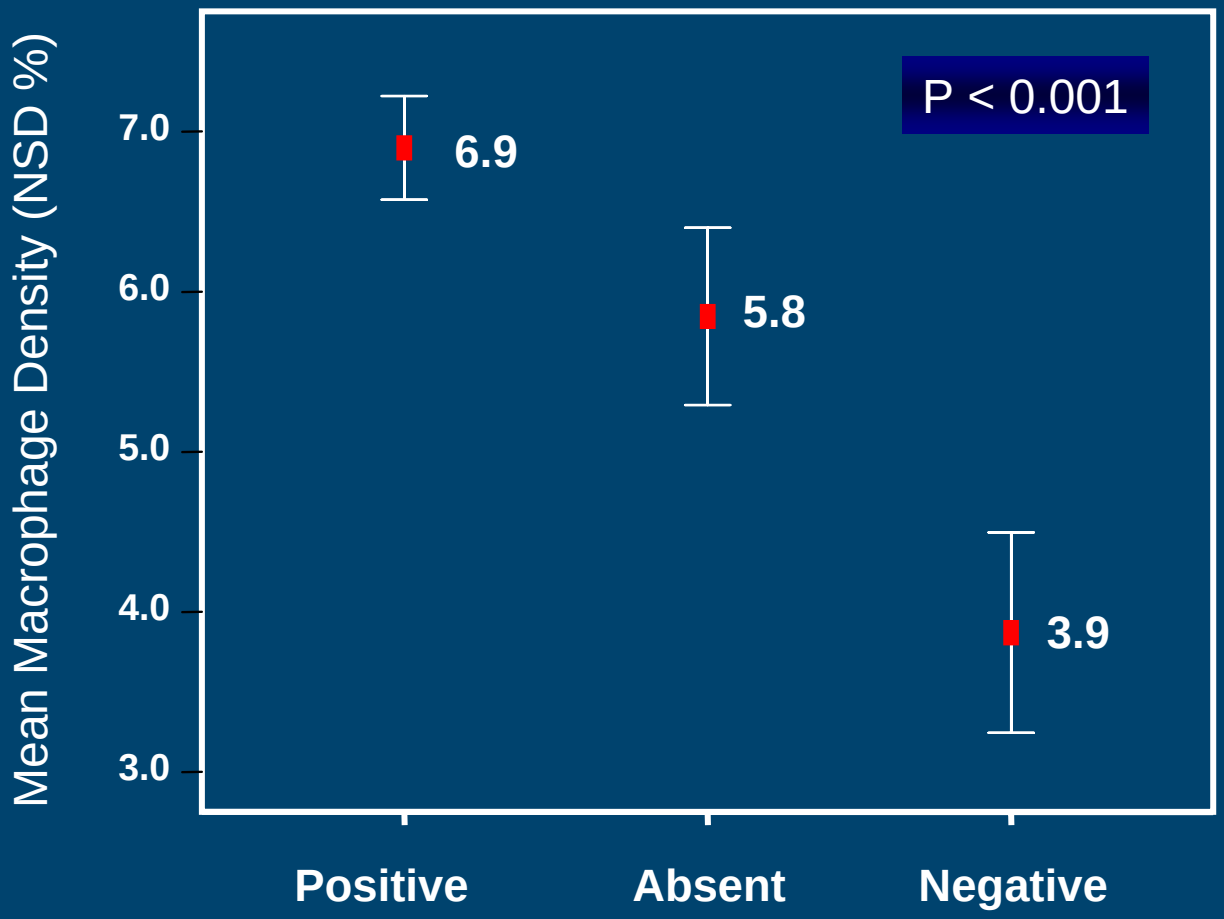
Remodeling vs Macrophage Density



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Limitations of OCT

1. Need to create blood free zone
2. No scanning capability – may miss
   ruptured site, thinnest cap, small lipid pool
3. Shallow penetration depth
4. Local, superficial anatomic information
5. No functional (physiologic) information

Raffel, Akasaka, Jang. Heart 2008
Low, Jang. Nature Cardiovasc Med. 2006

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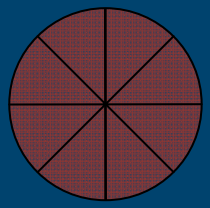
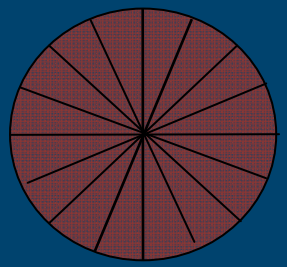
M3 vs C7(XR)

	M3	C7
Max. Frame Rate	20 fps	100+ fps
Max. Pullback Speed	3 mm/s	20+ mm/s
# Lines/frame	200	500
Scan diameter (in contrast)	6.8 mm	8+ mm
Lateral Resolution		
@ Z = 1 mm	30 µm	30 µm
@ Z = 3 mm	90 µm	40 µm
Axial Resolution	18 µm	12 µm

160,000 pixels/frame





500,000 pixels/frame

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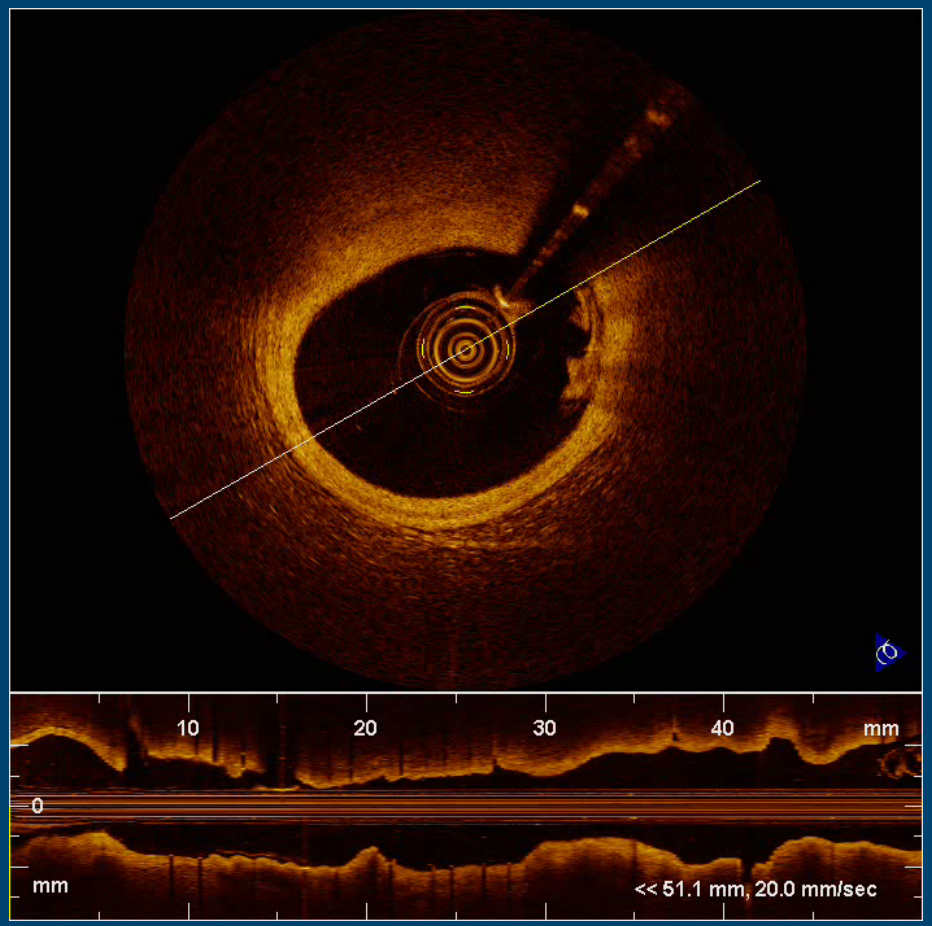
Frequency Domain OCT Pullback



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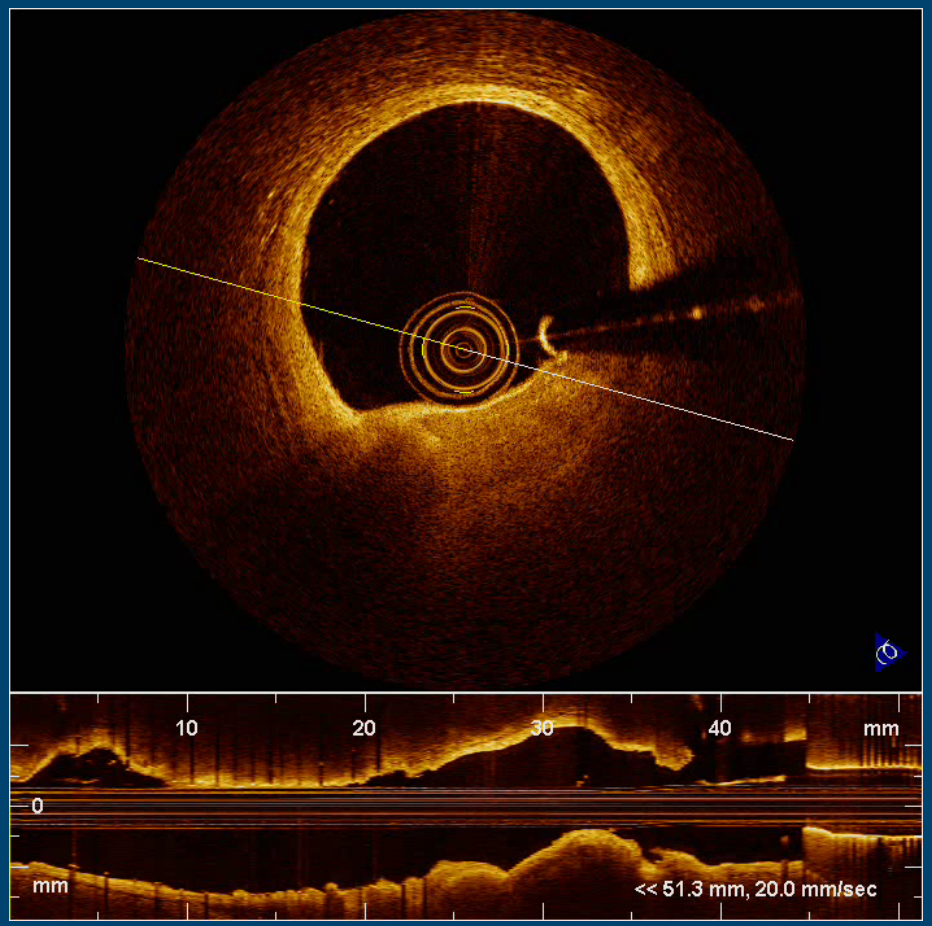
Frequency Domain OCT Pullback



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Clinical Study

- **Multicenter study**

- MGH
- Columbia University
- Stanford University

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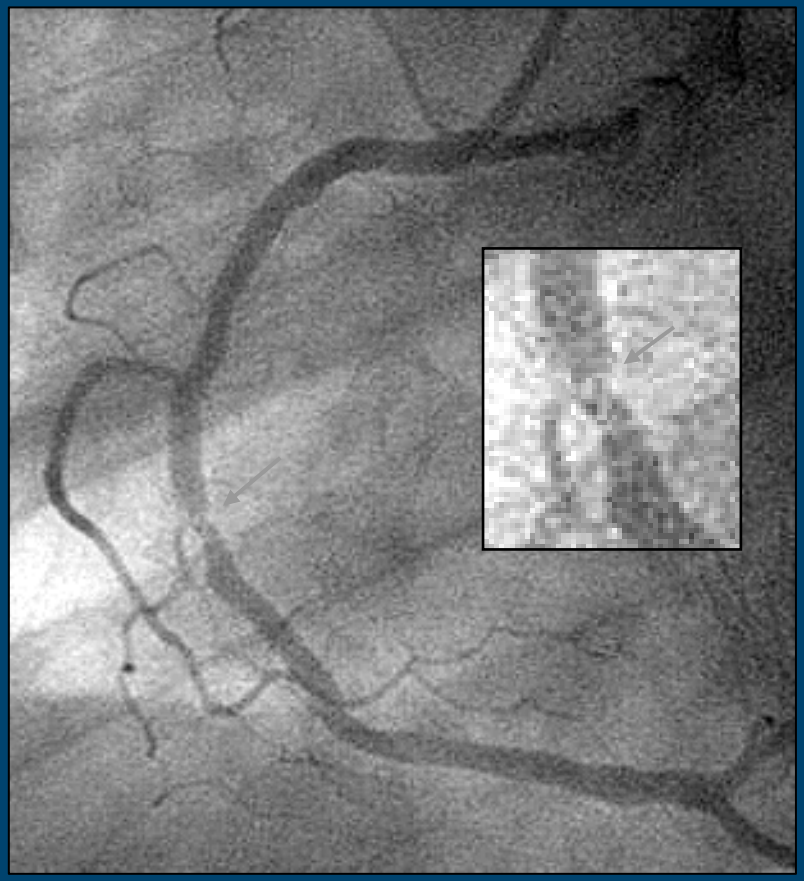
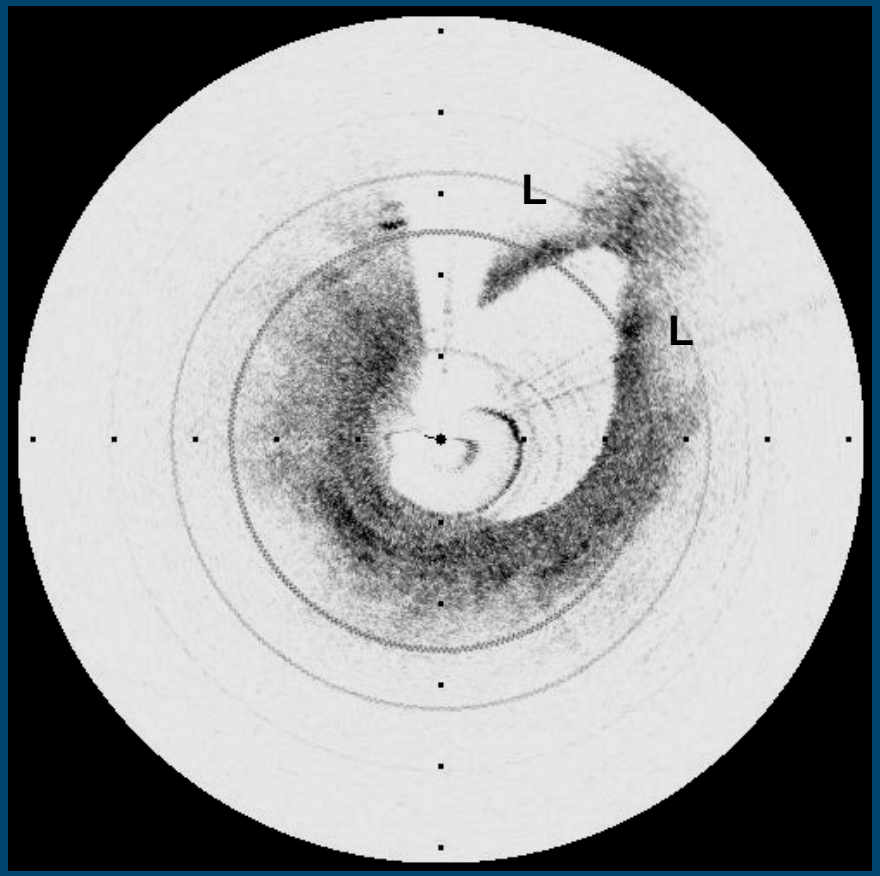
Post-AMI





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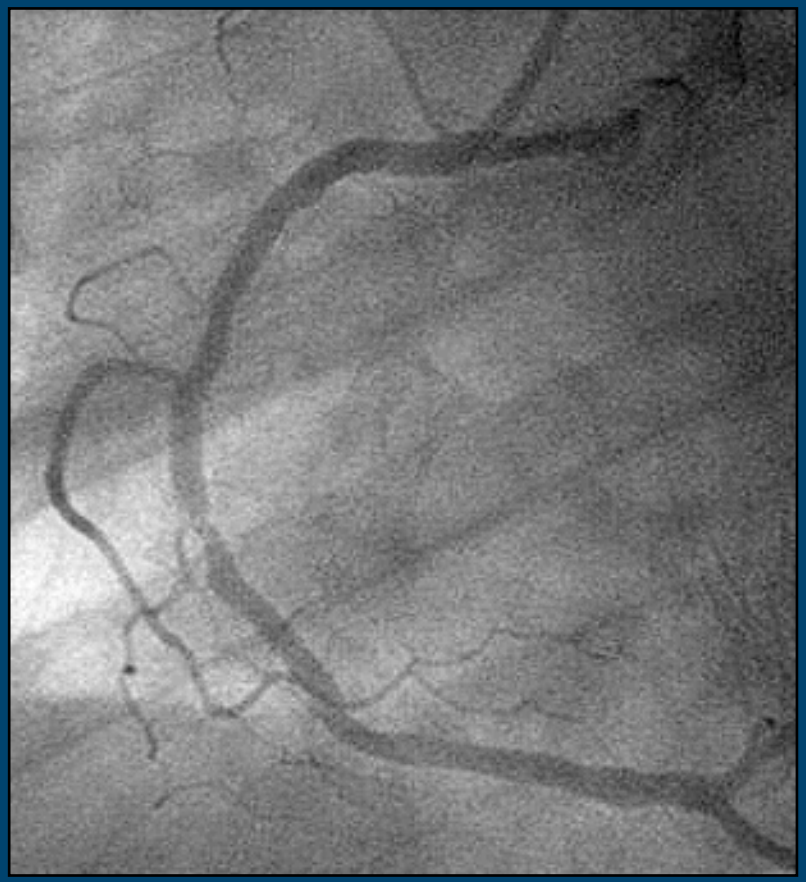
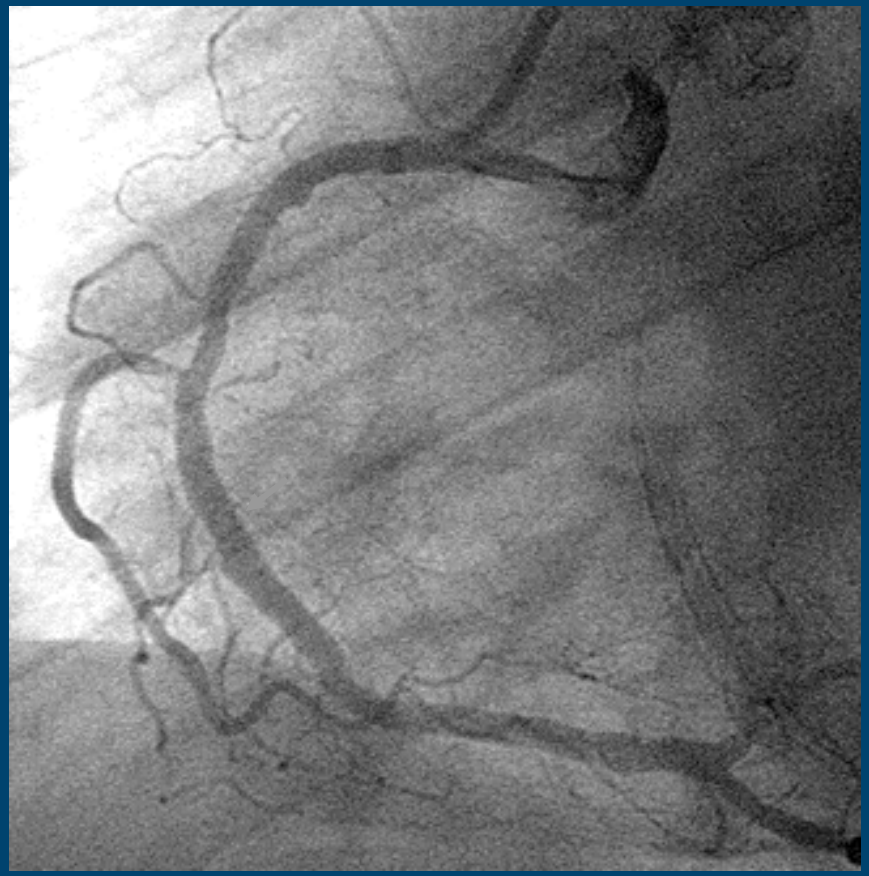
Post-AMI

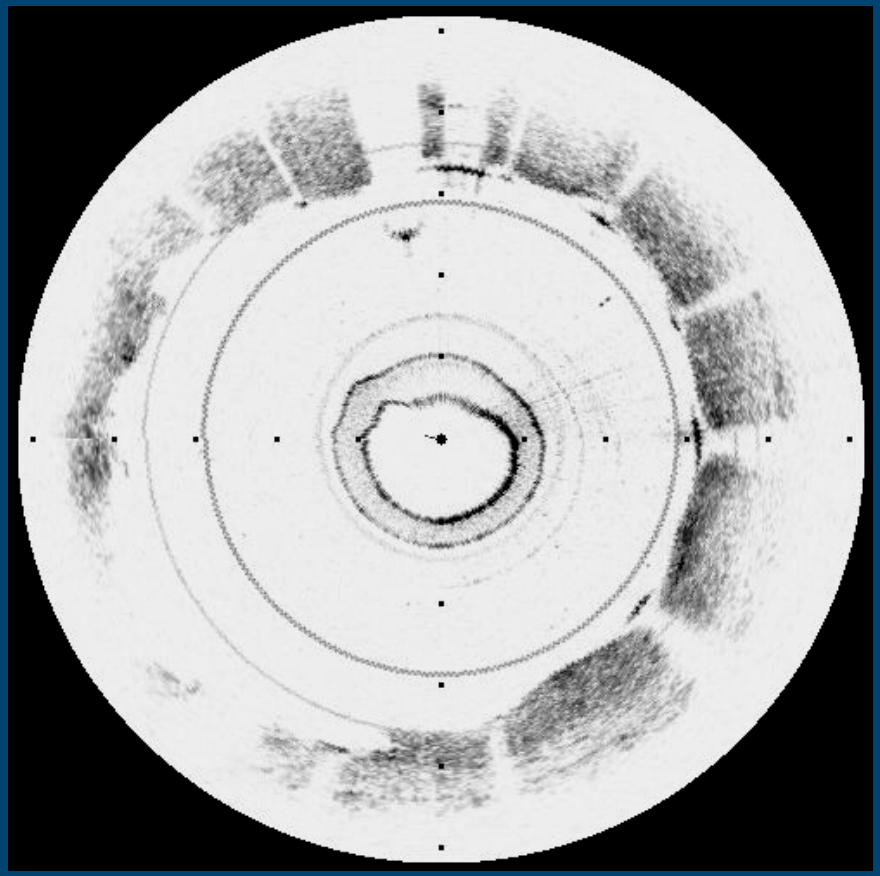


Pre PCI

Post PCI

Post-AMI





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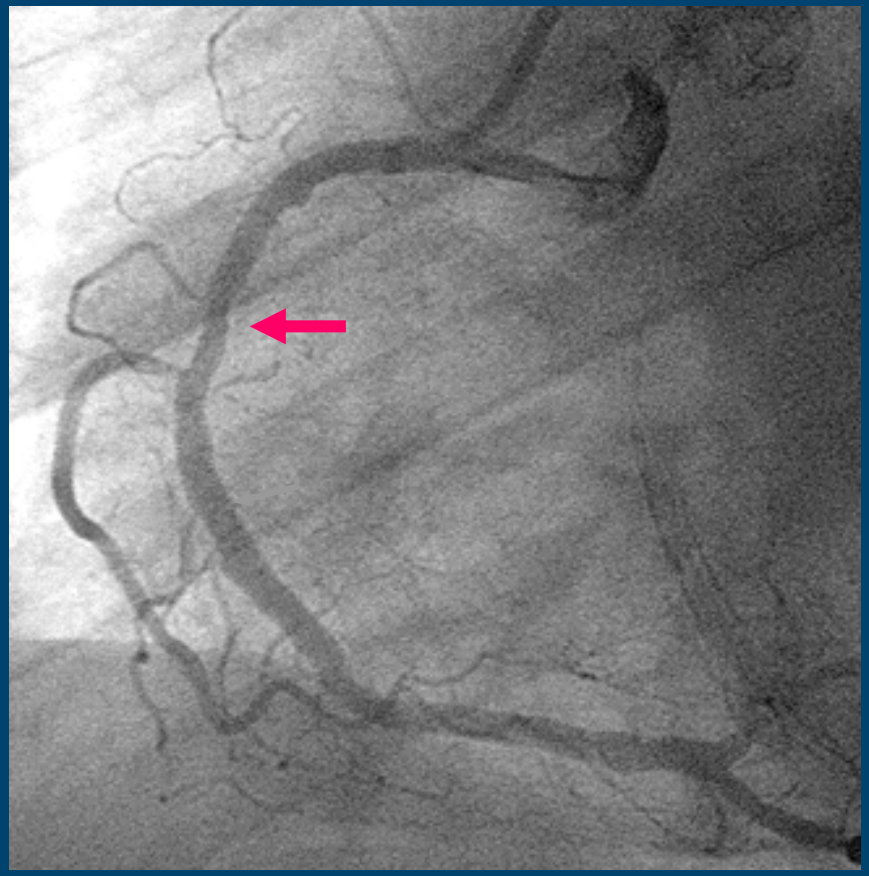
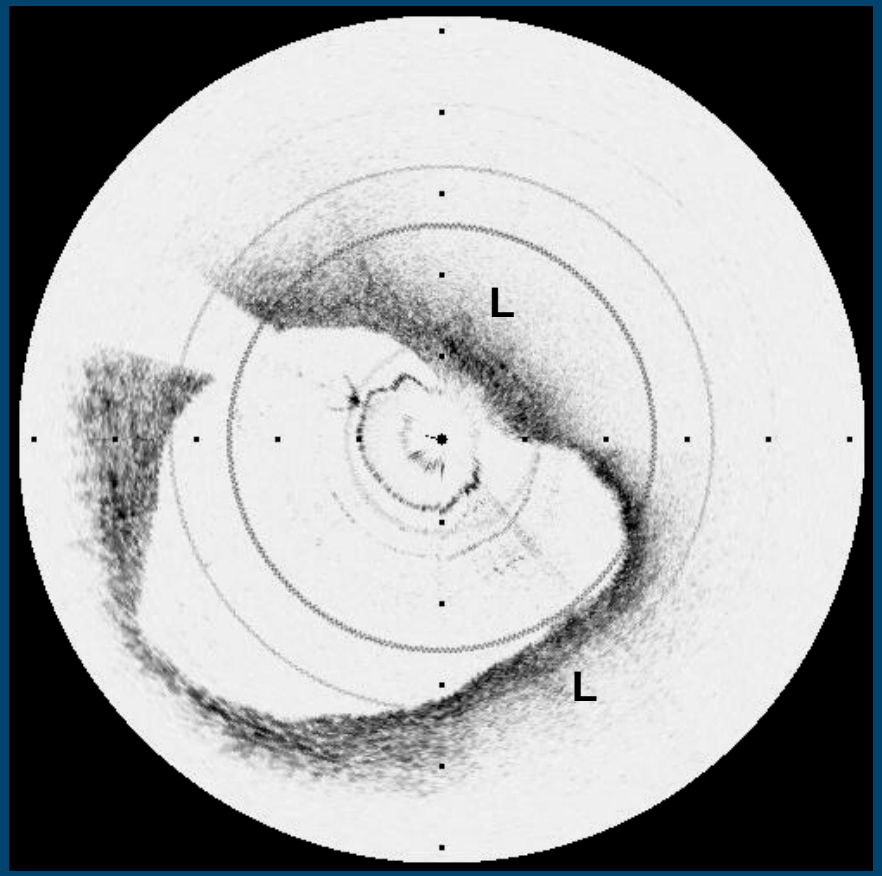
Post-AMI (Proximal to lesion)





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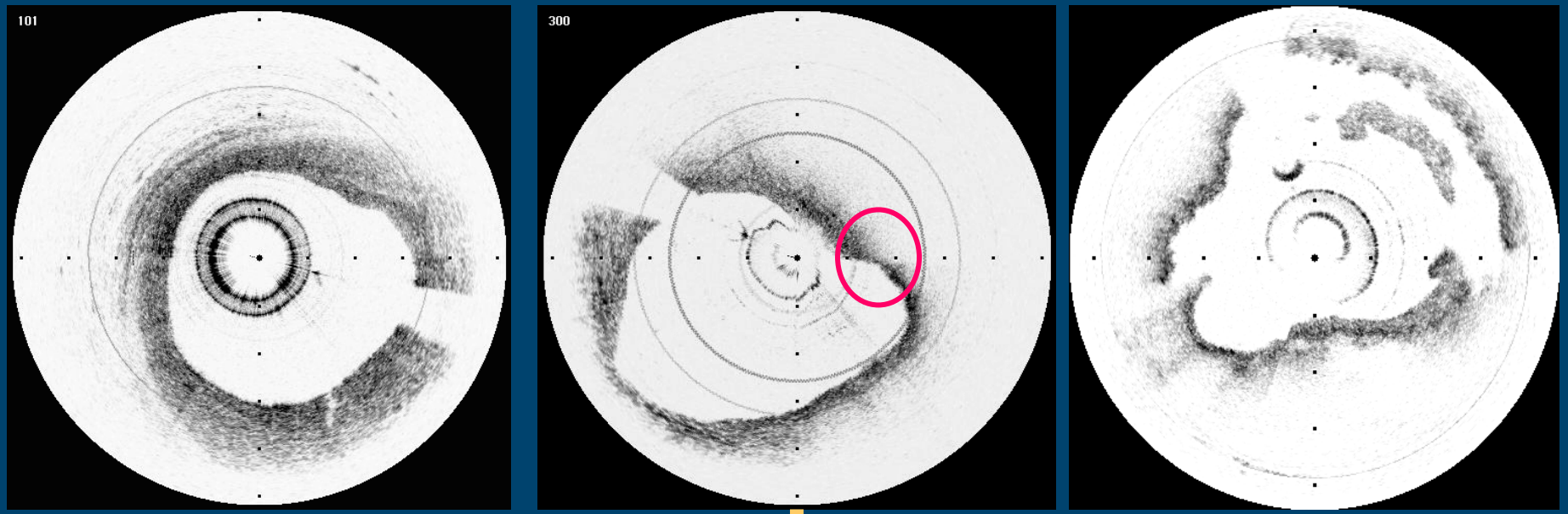
In-Vivo Plaque Morphology



Stable Plaque — TCFA — Ruptured Plaque

Study Date
April 2000

April 2004
No cardiac event.

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Detection of High-risk Plaque

Lack of Prospective Data !!!

OCT Research Group

- 20 Investigators from Australia, China, Hong Kong, Japan, Korea, USA
- Establishing Clinical Research Network
- Registry, Multi center studies
- Establish OCT fellowship
- Harvard University Continuing Education:
  -- OCT Research Group Symposium: 5/2010, Boston.

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Thank You

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